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**Welded Flash
Controlled Low
Carbon Steel Tubing
Normalized for
Bending, Double
Flaring, and Beading**

SAE Standard
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**WELDED FLASH CONTROLLED LOW CARBON STEEL TUBING NORMALIZED FOR
BENDING, DOUBLE FLARING, AND BEADING**

1. **SCOPE:** This standard covers normalized electric resistance welded flash controlled single wall low carbon steel pressure tubing intended for use as pressure lines and in other applications requiring tubing of a quality suitable for bending, double flaring, beading, and brazing.
2. **MANUFACTURE:** The tubing shall be made from a single strip of steel shaped into a tubular form, the edges of which are joined and sealed by electric resistance welding. After forming and welding, the outside flash shall be removed to provide a smooth surface. The inside flash shall be of uniform contour, free from saw tooth peaks, and controlled in height by seam welding techniques or by cutting, but not by hammering or rolling. The inside flash height shall conform to the following:

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Nominal Wall Thickness		Nominal Tubing Outside Diameter			
		Thru 1.000 (25.4 mm)		Over 1.000 (25.4 mm)	
		Maximum Flash Height ^a			
in	mm	in	mm	in	mm
Thru 0.035	0.90	0.005	0.13	0.010	0.25
Over 0.035 thru 0.065	0.90 thru 1.65	0.008	0.20	0.010	0.25
Over 0.065	1.65	0.010	0.25	0.010	0.25

^aFor tubes having an ID greater than 0.312 in (8 mm), the height of the inside weld flash shall be measured with a ball micrometer having an 0.156 ± 0.016 in (3.96 ± 0.41 mm) radius on the anvil or ball point. For tubes having an ID 0.312 in (8 mm) or less, screw thread micrometers shall be used. The height of the flash shall be the difference between the thickness of the tubing wall at the point of maximum height of the flash and the average of the wall thickness measured at points adjacent to both sides of the flash.

The tubing shall be normalized to produce a finished product which will meet all requirements of this standard.

- 3. DIMENSIONS AND TOLERANCES:** The tolerances applicable to tubing outside diameter are shown in Table 1. The tolerances applicable to tubing wall thickness are shown in Table 2. Particular attention shall be given to areas adjacent to the weld to insure against thin spots and/or sharp indentations.
- 4. QUALITY:** Lengths of finished tubing shall be reasonably straight and have smooth ends free from burrs. Finished tubing shall be free from scale and injurious imperfections and shall have a workmanlike finish. Outside surface imperfections such as handling marks, straightening marks, light die marks, or shallow pits shall not be considered injurious, provided the imperfections are not detrimental to the function of the tubing. The removal of such surface imperfections shall not be required.

The inside surface shall be free of weld splatter, pits, and all other injurious imperfections detrimental to the function of the tubing.

5. **MATERIAL:** Tubing shall be made from low carbon hot or cold rolled steel conforming to the chemical composition shown in Table 3. If rimmed steel is used, it shall be single strand. The steel shall be made by the open hearth basic oxygen, or electric furnace process. A ladle analysis of each heat shall be made to determine the percentages of the elements specified. The chemical composition thus determined shall be reported to the purchaser, or his representative, if requested, and shall conform to the requirements specified. If a check analysis is required, the tolerances shall be as specified in SAE J409, Table 3.
6. **Mechanical Properties:** The finished tubing shall have mechanical properties as tabulated below:

Yield Strength, min	25,000 psi (170 MPa)
Ultimate Strength, min	45,000 psi (310 MPa)
Elongation in 2 in (50 mm), min	35% ^a
Hardness (Rockwell B), max	65 ^b

^aFor tubing having nominal outside diameter of 0.375 in (9.5 mm) or less, and/or wall thicknesses of 0.035 in (0.9 mm) or less, a minimum elongation of 25% is permissible.

^bThe hardness test shall not be required on tubing with a nominal wall thickness of less than 0.065 in (1.65 mm). Such tubing shall meet all other mechanical properties and performance requirements.

7. **PERFORMANCE REQUIREMENTS:** The finished tubing shall satisfactorily meet the following performance tests. As designated therein, test specimens having minimum length equivalent to two times the tubing outside diameter or 2 in (50 mm), whichever is greater, shall be taken from finished tubing, as manufactured. All tests shall be conducted at room temperature.
- 7.1 **Flattening Test:** A test specimen shall be taken from every shipment or every 1500 ft (460 m), whichever is smaller, of finished tubing and flattened between parallel plates to a distance equal to three times the actual wall thickness of the specimen under test without any cracking or flaws. The weld shall be placed at 90 deg from the direction of applied force. Superficial ruptures resulting from minor surface imperfections shall not be considered cause for rejection.
- 7.2 **Reverse Flattening Test:** A test specimen shall be taken from every shipment or every 1500 ft (460 m), whichever is smaller, of finished tubing and split longitudinally 90 deg on each side of the weld. The section containing the weld shall be opened and flattened with the weld at the point of maximum bend. There shall be no evidence of cracks or metal flaking, or lack of weld penetration or overlaps resulting from flash control or flash removal in the weld.

- 7.3 Expansion Test: A test specimen shall be taken from every shipment or every 1500 ft (460 m), whichever is smaller, of finished tubing and subjected to expansion over a hardened tapered plug having a slope of 0.1:1.0 until the outside diameter has been expanded 25% without evidence of cracking or flaws.

The tubing shall be capable of being double flared as shown in SAE J533 without evidence of cracking or flaws. Refer to footnote b of Table 1 for tubing OD and wall thickness subject to this capability requirement. Double flaring tests shall not be required.

- 7.4 Hardness Test: One hardness test shall be made on a specimen from each production lot of tubing. The hardness test shall be made on the inside surface of the specimen. The hardness test shall not be required on tubing with a nominal wall thickness less than 0.065 in (1.7 mm). Such tubing shall meet all other mechanical properties and performance requirements.
- 7.5 Tensile Test: One tension test, in accordance with ASTM A 370, shall be made on a specimen from each production lot of tubing. If the percentage of elongation of the test specimen is less than that specified and/or any part of the fracture is more than 0.75 in (19 mm) from the center of the gage length, as indicated by scribe marks on the specimen before testing, a retest shall be allowed.
- 7.6 Pressure Proof Test: Unless otherwise specified, the finished tubing shall withstand a hydrostatic proof test, with no evidence of failure, at an actual pressure of 5000 psi (35 MPa) or at a fiber stress of 20,000 psi (140 MPa) whichever is less. Test pressures shall be determined by the following formula:

$$P = \frac{2TS}{D}$$

where: P = hydrostatic test pressure, psi (MPa) (5000 psi (35 MPa) max)
T = allowable minimum wall thickness of tubing, in (mm)
S = 20,000 psi (140 MPa) allowable fiber stress (80% of min yield strength)
D = nominal outside diameter of tubing, in (mm)

- 7.7 Nondestructive Electric Test: In lieu of the hydrostatic test, when mutually agreed upon by the purchaser and manufacturer, all tubing shall be tested by passing it through an electric eddy current tester which is capable of detecting defects that would prevent the tubing from passing the hydrostatic pressure proof test.
- 7.8 Test Specimens: Test specimens for mechanical tests shall be smooth on the ends and free from flaws. If any test specimen exhibits burrs, flaws or defective machining, before testing, it may be discarded and another specimen may be selected.
- 7.9 Test Certificate: A certificate of compliance to the performance requirements shall be furnished to the purchaser by the producer if requested in the purchase agreement.

8. CLEANLINESS: The inside and outside surfaces of the finished tubing shall be commercially bright, clean and free from grease, oxide scale, carbon deposits and any other contamination that cannot be readily removed by cleaning agents normally used in manufacturing plants.
9. CORROSION PROTECTION: The inside and outside surfaces of the finished tubing shall be protected against corrosion during shipment and normal storage. If a corrosion preventive compound is applied, it shall be such that after normal storage periods, it can be readily removed by cleaning agents normally used in manufacturing plants.

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TABLE 1 -- TUBING OUTSIDE DIAMETER TOLERANCE

Nominal Tubing ODa,b		Tolerance ±	
in	mm	in	mm
Thru 0.375	9.50	0.0025	0.06
Over 0.375-0.625	9.50-15.88	0.003	0.08
Over 0.625-1.125	15.88-28.57	0.0035	0.09
Over 1.125-2.000	28.57-50.80	0.005	0.13
Over 2.000-2.500	50.80-63.50	0.006	0.15
Over 2.500-3.000	63.50-76.20	0.008	0.20
Over 3.000-3.500	76.20-88.90	0.009	0.23
Over 3.500-4.000	88.90-101.60	0.010	0.25

^aOD measurements shall be taken at least 2.0 in (50 mm) from the end of the tubing.

^bRefer to SAE J514 for nominal tubing OD to be used in conjunction with standard hydraulic tube fittings and SAE J533 for recommended max nominal wall thickness for double flaring.

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TABLE 2 -- TUBING WALL THICKNESS TOLERANCES, IN

Nominal Wall Thickness ^a	Nominal Tubing Outside Diameter					
	Thru 1.000		Over 1.000 thru 2.000		Over 2.000 thru 4.000	
	Tolerance ^c					
	Plus ^b	Minus	Plus ^b	Minus	Plus ^b	Minus
0.028	0.002	0.003	0.003	0.003	0.004	0.003
0.035	0.002	0.004	0.003	0.004	0.004	0.004
0.049	0.002	0.005	0.003	0.005	0.004	0.005
0.065	0.004	0.006	0.005	0.008	0.006	0.008
0.083	0.004	0.006	0.006	0.008	0.007	0.008
0.095	0.004	0.006	0.006	0.010	0.007	0.010
0.109	0.004	0.006	0.008	0.010	0.009	0.010
0.120	0.004	0.008	0.008	0.010	0.009	0.010
0.134	0.004	0.008	0.008	0.010	0.009	0.010
0.148	--	--	0.008	0.011	0.009	0.011
0.165	--	--	0.008	0.011	0.009	0.011
0.180	--	--	0.008	0.011	0.009	0.011
0.203	--	--	0.008	0.012	0.009	0.012
0.220	--	--	0.008	0.012	0.009	0.012
0.238	--	--	0.013	0.018	0.014	0.018
0.259	--	--	0.013	0.020	0.014	0.020

^aFor intermediate wall thicknesses, the tolerance for the next heavier wall thickness shall apply.

^bPlus tolerances include allowance for crown on flat rolled steel.

^cMillimeter conversions of the inch tolerances are:

in	mm	in	mm	in	mm
0.002	0.05	0.007	0.18	0.012	0.30
0.003	0.08	0.008	0.20	0.013	0.33
0.004	0.10	0.009	0.23	0.014	0.36
0.005	0.13	0.010	0.25	0.018	0.46
0.006	0.15	0.011	0.28	0.020	0.51

TABLE 3 -- CHEMICAL REQUIREMENTS

Element	Cast or Heat Analysis, Wgt %
Carbon	0.18 max
Manganese	0.30 thru 0.60
Phosphorus	0.04 max
Sulfur	0.05 max

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